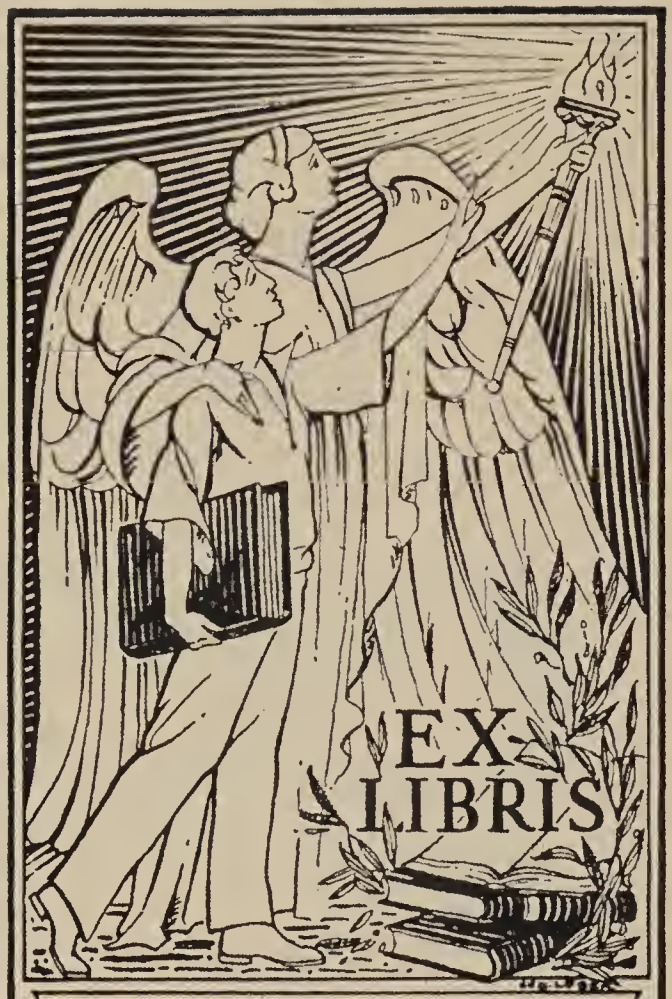

A GUIDELINE AND FORMULA FOR DETERMINING PROPER CANE LENGTH

by

Rona S. Lazarus, M.A. and Bruce B. Harrell

Assisted by

Linda McKinley, M.A. and Patrick Schwab, M.A.

The primary travel aid used today by the visually impaired population is the long cane, designed by Richard Hoover during World War II. The touch technique for using this cane was also begun at this time. It is the orientation and mobility instructor's job to instruct his client in using the cane in a safe and effective manner in order that he be able to travel independently through his environment. The long cane serves as a bumper and a probe as the user navigates indoors and outdoors. It is of the utmost importance that the visually impaired traveler have trust and confidence in the information his cane is relaying to him. In order for the cane to be the safe and efficient travel tool it should be, the question arises as to just how long this "long" cane should actually be. What is the proper cane length for an individual in order that he be adequately protected as he moves through his environment? Many factors must be considered. Previously the use of the sternum or breast bone as a reference point and guide determined one's "proper" cane length. It is apparent that this is quite an arbitrary reference point for cane length. There a variety of factors to consider beyond the height of a person from the ground to 1" above the base of his sternum. It is the purpose of this study to point out all of the various considerations a mobility instructor must look at before deciding on a safe and adequate cane length for each of his clients. The study will also include a mathematical formula for determining that safe length as well as guidelines in when and how to use such a formula.

It was determined initially that many students whose canes came up to their sternums were not ade-

Long Cane News, vol. 10, no 2. Nov. 1977
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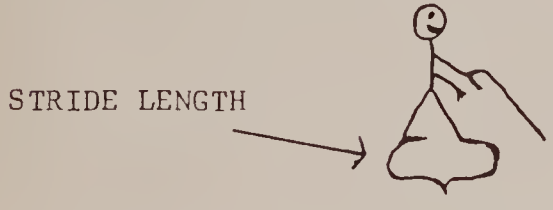
quately protected in using the touch technique. It was observed that they were overstepping their cane; thus not getting even one step warning time. Results of such a situation were: falling off of curbs, stepping onto the grass with the foot, contacting objects with the foot and body even though the arc of the cane was adequate. There was generally poor reaction time. It should be pointed out that such responses do not always indicate inadequate cane length. Reaction time can be a learned and developed process and such things as described above can occur with various individuals irregardless of length of cane. But many times when poor reaction time is observed, it can serve as a signal to observe just exactly where the foot is stepping in relation to the point where the touch technique strikes the ground. It is necessary to observe one side at a time as it can vary from the left to the right foot. This procedure can be done by following one's client very closely and keeping one's eye on the exact spot where the cane touched the ground and watching where the foot on that side lands in the next step. It can best be observed after the client has built up a normal walking pace--preferably over a flat area of cement. A more exact check can be done in smooth, packed, wet sand where the exact point of the cane tip and footprint can be carefully observed. Another alternative would be to use chalk on the end of the cane and dust the bottom of the student's feet so that his steps are marked as he walks. All of the above procedures are in reference to stride---a most important factor in determining cane length. It should be noted that stride does not necessarily relate to height of a person or to length of legs---stride can vary greatly from person to person.

A second important factor to consider is the height at which the cane is held off the ground. As the cane is actually an extension of one's arm, it can be noted that length of arm is a relevant factor affecting how far the cane is held from the ground when the arm is fully extended and the cane is centered. A person with very long arms would not need as long a cane as another person of the same height whose arms were several inches shorter. Thus height of hand from the ground has a definite effect on the length of one's cane.

A third factor that is necessary to consider is that of confidence level as it relates to length of stride and rate of travel. It can be noted that length of stride tends to increase as the level of confidence in one's travel increases. It is the more unsure traveller who tends to take small steps as he moves through the environment--often the fearful mobility student who has not done a great deal of free movement on his own. The use of the cane as a probe and a bumper into the environment is often a new experience and can make the user overly cautious until he becomes more comfortable with it. Thus it appears that stride lenght can change as confidence is developed. Although speed or rate of travel often develops simultaneously with stride length, it actually has no direct relationship to cane length. Increased speed may give one reason to develop quicker reaction time, but as long as his stride length is the same he will still be adequately protected by his cane as long as he is not overstepping it.

With the above factors in mind, a guideline as to when and how to determine a student's proper cane length has been devised. It was decided that as long as the student had one step warning time--that is, the length of his one stride came behind the point where his cane touched the ground--he would be adequately protected. As long as, after taking a step, his toe of the forward foot did not go beyond this point of the cane, he would be safe and would thus have at least one full step warning time. Considering the fact that stride length may change as confidence and experience develop in the use of the cane, it is recommended that proper cane length cannot effectively be determined until one's client has reached his maximum comfortable walking stride. It is suggested that such a stride could possibly be developed by the second week in residential travel, although this time will vary from student to student. Using this estimate as a rough guideline as to when proper cane length can safely be determined, the mobility instructor can be flexible in using his judgement for each new student. Initially, the first cane given will have to be based on estimation until the use of the guideline will prove relevant. Periodic reevaluation may be necessary as the student progresses through the program.

The first step in determining proper cane length is measuring length of stride. This is done when the mobility instructor feels his student has developed a comfortable, natural walking stride. This measurement can be taken by having the student walk 15-25 steps on a flat smooth surface with no obstacles to encounter, and then have him stop in motion and measure the length of his stride. It should be checked with the right and the left foot forward and the longest stride length should be used for this measurement. A more accurate measurement can be taken by using the wet sand or chalk methods as described earlier or by measuring off an area of sidewalk and counting the student's steps from beginning to end and dividing the number of steps into the measurement of the test area. For the purpose of this study, measurement of stride length refers to the distance from the heel of the back foot to the toe tip of the front foot.



The next step is to determine the height of the distance between the cane and the ground. To obtain a perpendicular line to use in later calculations, it was observed that the line between the elbow joint when the arm is extended and held straight and centered (for proper touch technique) and the tip of the toes with both feet together and standing up straight is a straight line and forms a 90 degree angle with the ground. Therefore the second step is to hold the arm in this position and keep the feet together, knees straight and to take the measurement of the distance between the elbow (using the center of the elbow by following the main crease around the arm) to the toe point on the ground. This can be easily done by using a straight object to mark off the distance (can use another cane) and then measure this distance.

The third step is to hold the cane in the proper position for touch technique and measure the distance from the center of the elbow to the top of the cane (top of the crook--the highest point of the cane from the ground).

After measuring and recording these three figures, the Pythagorean Theorem ($\sqrt{a^2 + b^2}=c$) can be used at this point to comupte the proper cane length for this individual.

$\sqrt{a^2+b^2}=c$

The following are the steps to be taken:

(1) Square the number obtained for stride length--a.
(2) Square the number obtained for height from elbow to ground--b.
(3) Add these two figures together--a^2+b^2.
(4) Take the square root of this number---$\sqrt{a^2+ b^2}$.
(5) Now you will have c--the distance from the elbow to the cane tip on the ground--$\sqrt{a^2 + b^2}=c$.
(6) In order to obtain proper cane length for this individual, it is necessary to subtract the forearm length (from elbow to top of cane) from c. c - length of forearm=cane length

The result is a safe and adequate length of cane in order to give this student one step warning time as he travels through the environment.

Examples of such a calculation where adequate cane length was figured for various students will be given. (Note and compare measurement when sternum was used as a guideline.)

Student A

Height of student = 6 feet
Length of stride = 49 inches = a
Length of distance between elbow and toe on ground = 47 inches = b
Length of forearm--elbow to top of cane = 10 inches

$\sqrt{49^2 + 47^2} = \sqrt{4600} = 68$ (rounded off to nearest inch)

68 inches = c 68 inches - 10 inches = 58 inches
Ground to one inch above base of sternum = 55 inches
Adequate cane length for Student A = 58 inches

Student B

Height of student = 5 feet 7 inches
Length of stride = 37 inches = a
Length of distance between elbow and toe on ground = 43 inches = b
Length of forearm--elbow to top of cane = 8 inches

$\sqrt{37^2 + 43^2} = \sqrt{3210} = 57$ (rounded off to nearest inch)

57 inches = c 57 inches - 8 inches = 49 inches
Ground to one inch above base of sternum = 51 inches
Adequate cane length for Student B = 49 inches

Student C

Height of student = 5 feet 4 inches
Length of stride = 37 inches = a
Length of distance between elbow and toe on ground = 43 inches = b
Length of forearm--elbow to top of cane = 6 inches

$\sqrt{37^2 + 43^2} = \sqrt{3218} = 57$ (rounded off to nearest inch)

57 inches = c 57 inches - 6 inches = 51 inches
Ground to one inch above base of sternum = 47 inches
Adequate cane length for Student C = 51 inches

Student D

Height of student = 6 feet
Length of stride = 38 inches = a
Length of distance between elbow and toe on ground = 49 inches = b
Length of forearm--elbow to top of cane = 10 inches

$\sqrt{38^2 + 49^2} = \sqrt{3845} = 62$ (rounded off to nearest inch)

62 inches = c 62 inches - 10 inches = 52 inches
Ground to one inch above base of sternum = 54 inches
Adequate cane length for Student D = 52 inches

Student E

Height of student = 5 feet 8 inches
Length of stride = 45 inches = a
Length of distance between elbow and toe on ground = 46 inches = b
Length of forearm--elbow to top of cane = 9 inches

$\sqrt{45^2 + 46^2} = \sqrt{4141} = 64$ (rounded off to nearest inch)

64 inches = c 64 inches - 9 inches = 55 inches
Ground to one inch above base of sternum = 51 inches
Adequate cane length for Student E = 55 inches

Student F

Height of student = 6 feet 2 inches
Length of stride = 46 inches = a
Length of distance between elbow and toe on ground = 50 inches = b
Length of forearm--elbow to top of cane = 10 inches

$\sqrt{46^2 + 50^2} = \sqrt{4616} = 68$ (rounded off to nearest inch)

68 inches = c 68 inches - 10 inches = 58 inches
Ground to one inch above base of sternum = 55 inches
Adequate cane length for Student F = 58 inches

Student G

Height of student = 5 feet 8 inches
Length of stride = 37 inches = a
Length of distance between elbow and toe on ground = 46 inches = b
Length of forearm--elbow to top of cane = 7 inches

$\sqrt{37^2 + 46^2} = \sqrt{3485} = 59$ (rounded off to nearest inch)

59 inches = c 59 inches - 7 inches = 52 inches
Ground to one inch above base of sternum = 51 inches
Adequate cane length for Student G = 52 inches

Student H

Height of student = 5 feet 4 inches
Length of stride = 28 inches = a
Length of distance between elbow and toe on ground = 43 inches = b
Length of forearm--elbow to top of cane = 8 inches

$\sqrt{28^2 + 43^2} = \sqrt{2633} = 51$ (rounded off to nearest inch)

51 inches = c 51 inches - 8 inches = 43 inches
Ground to one inch above base of sternum = 48 inches
Adequate cane length for Student H = 43 inches

Student I

Height of student = 6 feet
Length of stride = 35 inches = a
Length of distance between elbow and toe on ground = 46 inches = b
Length of forearm--elbow to top of cane = 10 inches

$\sqrt{35^2 + 46^2} = \sqrt{3341} = 58$ (rounded off to nearest inch)

58 inches = c 58 inches - 10 inches = 48 inches
Ground to one inch above base of sternum = 52 inches
Adequate cane length for Student I = 48 inches

Student J

Height of student = 5 feet 10 inches
Length of stride = 36 inches = a
Length of distance between elbow and toe on ground = 48 inches = b
Length of forearm--elbow to top of cane = 9 inches

$\sqrt{36^2 + 48^2} = \sqrt{3600} = 60$ (rounded off to nearest inch)

60 inches = c 60 inches - 9 inches = 51 inches
Ground to one inch above base of sternum = 52 inches
Adequate cane length for Student J = 51 inches

It can be observed from these examples that height of the student is not the primary factor to consider in determining proper cane length--the varying factors of stride, length of arm, etc. obviously must be taken into consideration as they have a direct effect on the warning time one receives from his cane. It appears from these results that the use of the sternum as a guideline (thus based on height) is not always the safest and most accurate reference to use. The ramifications of a cane that is too short and does not allow enough warning time to the user go beyond the fact that many a curb may be overstepped. With constant surprises and unexpected contact with the environment, one appears to be awkward and clumsy in his travel rather than being the smooth traveller that is desired. With such occurrences happening often enough, one's own self-confidence could slowly be torn down. The importance of self-confidence cannot be overemphasized for the independent traveller. It could be quite harmful

to the blind individual if his confidence level is not being built up due to a cane that is too short.

One might argue that by extending an individual's cane several more inches, particularly someone who needs an extra long cane, the problem of the cane getting in the way of others is more prevalent. If this is the case, modifications in one's normal travel habits may need to be made. The person with the longer cane can slow his pace down in crowds and selectively shorten his cane using the congested area cane technique when needed as he takes smaller steps. The blind person using a cane should always be more cautious of others in such a crowded pedestrian situation anyway. In weighing the factors, it would seem more reasonable to be safer and smoother the majority of the time with the longer cane and to just be more careful when using the cane in a crowded area. Upon using the formula, it could be determined that a student's cane was much longer than he actually needs due to an extra short stride or long arms. If this were the case, a shorter cane could be used to prevent so much pedestrian contact while at the same time the student would still be getting adequate warning time.

It is the purpose of this study to aid the mobility instructor in determining the safe and adequate cane length for each of his individual students by offering all of the possible considerations that should be taken into account. After considering all the factors mentioned, the instructor may choose to use the mathmematical formula explained to insure the safe length of each student's cane. There are so many variables that a mobility instructor is unable to control that have an influence on the successes and failures of his students. Cane length is one of the factors which a perceptive mobility specialist can control and manipulate to suit the needs of each of his clients and possibly build more successes as a result. The importance of proper cane length cannot be underestimated as it can affect the user's appearance, safety, efficiency, self-confidence, and independent travel on the whole.